National Bureau of Standards

TECHNICAL NEWS BULLETIN

VOLUME 34 NOVEMBER 1950 NUMBER 11

Salinimeter for Density Currents

A salinity meter that is inexpensive, easily constructed, and adaptable to a wide range of conditions both in the field and in the laboratory has been designed by Dr. Garbis H. Keulegan of the National Bureau of Standards. The instrument, known as a salinimeter, records salinities at varying depths in either a stationary or a flowing body of water. Although originally designed for laboratory use, it may be easily adapted to observations in rivers and internal navigation channels.

A typical problem for the salinometer would be the measurement of salt water intrusion from the Atlantic Ocean into Chesapeake Bay or from the Bay into a river. The dispersion of salt in an internal navigation channel behind a lock can also be measured with the instrument.

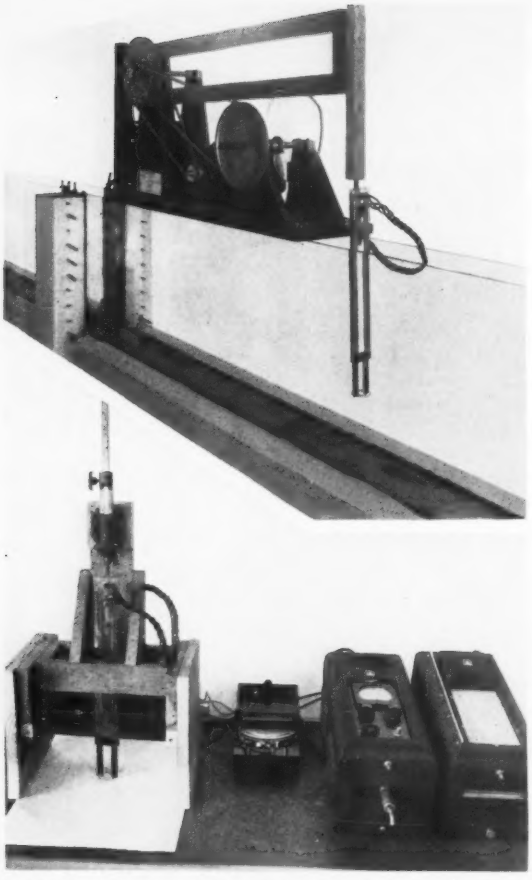
In order to study these and similar problems, Bureau engineers have constructed a series of channels connected by means of watertight gates to larger tanks, representing oceans. At the start of an experiment, a tank is filled with salt water. Fresh water is then allowed to flow through the channel at a rate corresponding to the current in the waterway for which the data are being calculated. When the gate is opened, the salt water, being heavier than fresh water, flows under the water in the channel, forming a rounded "front." Below and behind this front, the water is salt. As the front proceeds down the channel, it ceases to be a sharp line of demarcation and becomes an increasingly thick zone of mixing between fresh and salt water. A vertical cross section of the channel then reveals fresh water at the top, salt water at the bottom, and all degrees of salinity, increasing with depth, in between. The salinimeter is used in making this vertical cross-sectional measurement.

The most convenient method for determining the salinity of a solution is to measure its electrical conductivity. The salinimeter operates on this principle. Since the cross-sectional dimensions of the model channels are small, the electrodes must lie as nearly as possible in one plane in order to yield a dependable reading for a given depth. The space between the electrodes must also be small, as the concentration of salt varies rapidly in the channel. At the same time, the area of the electrodes must be as large as possible. To meet these requirements, an electrode was designed that consists of two concentric circles of 18-gage copper wire, spaced 6 millimeters apart and averaging about 6 centimeters in length.

A theoretical analysis showed that the resistance of two parallel wires immersed in an electrolytic solution is a function of the conductance of the solution and the length, spacing, and diameter of the wires. Then to measure the reliability of such an instrument as a salinimeter, tests were made on sodium chloride solutions of known values. The results agreed with the theoretical values within limits of ± 5 percent.

In the laboratory, the salinimeter is calibrated with salt solutions prior to operation in the channel. Corrections are also made for temperature differences between test solutions and channel solutions.

911133—50



NBS scientists have designed this simple, efficient salinity meter for measuring the amount of intrusion of salt water into a channel of swiftly flowing fresh water (top), or the dispersion of salt water in a static body of fresh water (bottom). The vertical arm of the instrument (top), controlled by a motor-driven heart-shaped cam, raises and lowers two circular, copper-wire electrodes though the water in the glass-walled channel. The meter (bottom, left) is mounted on a graduated arm that is raised or lowered manually. Leads from the electrodes are connected to the secondary of a transformer giving a 6-volt, 60-cycle current. A shunt is connected to an oscillograph recorder through an amplifier.

The device may be used with two different assemblies. If the test solution is fairly static, the electrodes are attached to a manually operated arm, by which the electrodes are lowered to any depth at which a reading is desired.

For fast-moving currents, where rapid vertical variations are expected, the electrodes are mounted on an arm that rides on a motor-driven, heart-shaped cam. The measuring element is thus lowered and raised at a uniform rate over the entire vertical extent of the water in the channel. An oscillograph recorder connected to the electrodes produces a continuous, wavelike trace, the crests of which correspond to high-salinity values.

TECHNICAL NEWS BULLETIN

U. S. Department of Commerce

Charles Sawyer, *Secretary*

National Bureau of Standards
E. U. Condon, *Director*

NOVEMBER 1950 Issued Monthly Vol. 34, No. 11

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price, domestic, $1.00 a year; foreign, $1.35; single copy, 10 cents. The printing of this publication has been approved by the Director of the Bureau of the Budget, February 3, 1950.

Contents

Research on Dental Materials at The National Bureau of Standards

A new publication, recently issued by the National Bureau of Standards, describes the work of the Bureau's Dental Research Laboratory in improving dental materials and techniques. The booklet gives a general account of the work done on such subjects as physical and chemical properties of dental materials, structure of tooth enamel and dentin, clinical research, specifications for and certification of dental materials, the education program, and special problems for the armed services. Also included is a list of 156 Bureau publications on dental materials that constitute the most extensive set of reference material ever produced in any dental research laboratory.

Circular 497, *Research on dental materials at the National Bureau of Standards*, 14 pages, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 15 cents a copy.

NBS Computation Laboratory

With the completion of SEAC (the National Bureau of Standards Eastern Automatic Computer) and the acquisition of several new types of punched-card computers, the National Bureau of Standards Computation Laboratory is now provided with the most up-to-date equipment available for carrying out its function as a centralized national computational facility. As a result, solutions are rapidly being obtained for problems in science, engineering, and administration that would have required a prohibitive amount of time by desk-machine methods.

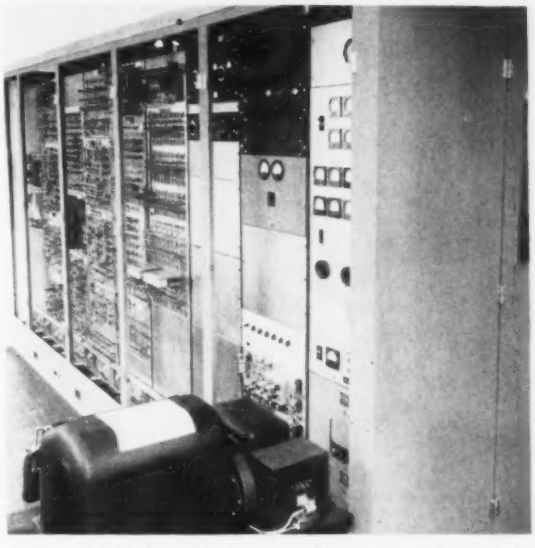
The functions of the NBS Computation Laboratory are quite broad. In addition to performing computations requested by Federal agencies, universities, and private industries, the Computation Laboratory works continuously to create a stockpile of mathematical tables that can be used to facilitate such computations. At the same time, an effort is made to develop new or improved techniques for numerical computation, particularly those adaptable to automatic computing machines, and to train mathematicians, both within the Laboratory and in other parts of the Bureau, in the application of numerical methods. In this way, the use of mathematical techniques for the solution of technical problems is promoted and extended, bringing increased effectiveness to the national research program.

The Computation Laboratory is one of four laboratories which together make up the Bureau's Applied Mathematics Division, established in 1946 with the support of the Office of Naval Research. The Division also includes the Institute for Numerical Analysis, Machine Development Laboratory, and Statistical Engineering Laboratory. In general, the NBS Computation Laboratory seeks to complement rather than to displace the activities of other applied mathematics and computation groups. Many laboratories, for example, have their own computing facilities but are unable to undertake projects requiring large, specialized equipment. Others need aid in handling peak loads or require periodic mathematical assistance in order to utilize their facilities to the best advantage. Still others require mathematical computation and analysis work, but not in sufficient volume to justify the expense and added responsibility of setting up their own computing services. For all these laboratories, the program of the Computation Laboratory fills a definite need. Although the services of the Laboratory are furnished chiefly to Federal agencies, work is also performed, under certain circumstances, for industrial laboratories and universities.

Many important scientific and engineering problems that the Computation Laboratory is thus called upon to solve will be completed in a much shorter time through the use of SEAC, the Bureau's new high-speed automatically sequenced electronic computer [SEAC, The National Bureau of Standards Eastern Automatic Computer, NBS Technical News Bulletin **34**, 121 (1950)]. In addition to SEAC, a second machine, the National Bureau of Standards Western Automatic Computer (SWAC), has now been completed in NBS Los Angeles Laboratories. A full description of SWAC will be published in an early issue of the NBS Technical News Bulletin]. Once it has been supplied with coded instructions and numerical data, this general-purpose machine automatically performs all of the logical and arithmetical operations required to solve a particular problem. By combining a vast number of simple operations into a complex, high-speed sequence, it can calculate the answers to many difficult computational and statistical problems whose solutions otherwise would be impractical in any reasonable time or energy sense.

The preparation of an instruction program for a problem to be solved on SEAC requires a great deal of skilled work by specially trained mathematicians. But once the program for a particular kind of problem has been coded, it can be used over and over again with different sets of numerical data. The change-over from one type of problem to another is accomplished by sending in a new set of instructions through the input-output unit. No rewiring or switch-setting is required. Instructions previously read into the machine may also be altered without complete erasure. This simplifies the preparation of problems, as less complete instructions are needed initially.

For those problems that are too large for manual computing methods and yet not large enough to make the use of SEAC practical, the new punched-card machines are proving invaluable. In these machines, which were constructed by the IBM Corporation, numbers are represented by holes punched in cards. When



A view of SEAC with input and output equipment in foreground. The teletype keyboard and printer are used for direct input and output with numbers and instructions coded in hexadecimal notation. Indirect operation is also possible through the use of punched paper tape.

Type 082 Electronic Sorter, one of the newest IBM machines. Cards punched to represent numerical data are sorted electronically in the NBS Computation Laboratory before they are run through an IBM punched-card computer.

a deck of cards is run through one of these machines (known as a "Type 604") it reads several numbers from each card, performs a prescribed sequence of additions, subtractions, multiplications, or divisions, and punches one or more of the answers obtained into unused portions of the card. It will also, if desired, store some of the answers for use in connection with the data read from the next card.

Cards are fed at the rate of 100 per minute. In other words, in 0.6 second the machine feeds a card, reads the numbers punched in it, and performs a fairly long sequence of arithmetic operations. The results of these operations are punched into the card while the next card is being read. This speed is made possible by the use of electronic circuits for computing.

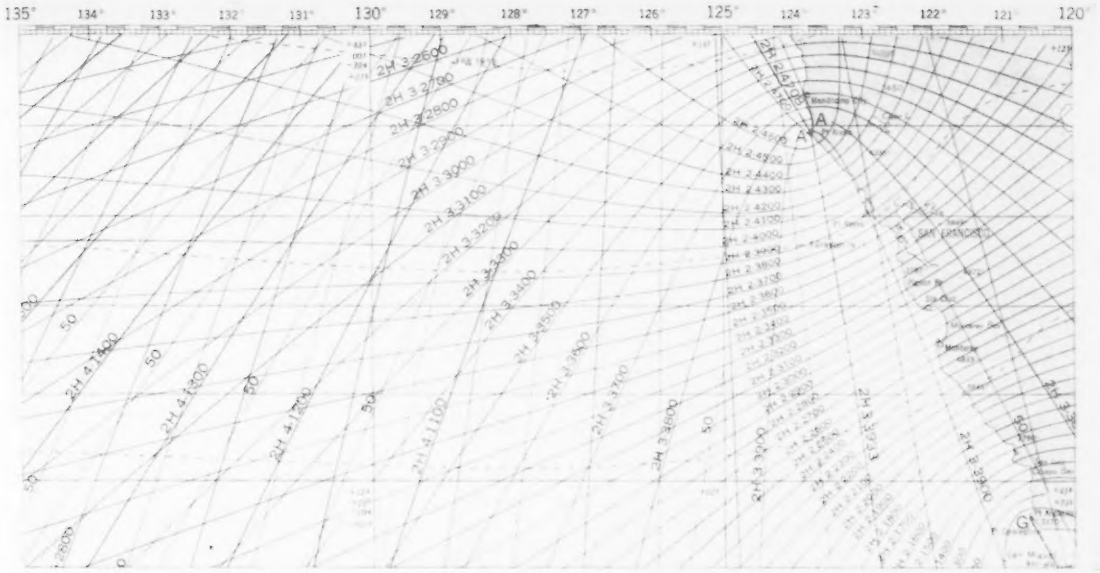
The newest machine of this type acquired by the Bureau, the Card-Programmed Calculator, represents a radical departure from conventional punched-card machines in that "programming"—the giving of instructions to the machine—is accomplished by means of cards. Standard machines use cards only to represent numbers, and the particular operation or sequence of operations to be performed is determined in advance by the position of wires that the operator inserts in a plugboard. Thus the computing routine cannot, in general, be changed without stopping the machine and performing time-consuming manipulations. In the Card-Programmed Calculator, on the other hand, the holes punched in the cards are used to signify both numbers and instructions to the machine. By feeding cards carrying the appropriate punched code, a nonrepetitive sequence of operations of any desired length can be carried out. Plugboards are also provided to take care of those elements of the computation that are repetitive.

In addition to the Card-Programmed Calculator and four 604's, the Computation Laboratory has new types of electronic sorters and typewriters, as well as a battery of standard auxiliary machines. A card-controlled typewriter specially designed for producing mathematical tables is being acquired.

Of the various activities carried on by the Computation Laboratory, it is expected that research directed toward improved computing techniques will pay the greatest dividends in the long run. Much of this work is being made necessary by the introduction of the large-scale electronic computers such as SEAC. For example, the solution of systems of linear equations in many unknowns without the aid of automatic computing machines would require so many man-hours of computing labor that it is not even attempted. Yet if a direct solution with automatic machines is tried, it is frequently necessary to carry all computations out to a large number of decimal places; otherwise the accumulated error caused by "rounding-off" at each intermediate computing step grows very large, and the results are meaningless. The number of decimal places that must be carried depends on the "condition" of the system of equations. For this reason, the manner in which the condition is affected by certain mathematical transformations has been studied extensively by the Computation Laboratory.

Typical of the computations that have been performed by the Laboratory in connection with specific

The IBM Card-Programmed Calculator is proving very useful in the NBS Computation Laboratory for performing computations which, while extensive, are not quite large enough for SEAC. The machine consists of four components. Foreground: tabulator. Background (left to right): Summary punch, arithmetic unit, memory unit.



Data for loran navigation charts issued by the Navy's Hydrographic Office are calculated by the NBS Computation Laboratory. Based on hundreds of thousands of involved computations, these charts simplify the work of the air or sea navigator so that a loran fix can be obtained in a very few minutes.

problems in applied mathematics was the solution of complicated systems of simultaneous nonlinear equations describing the shock waves that follow an explosion. The ultimate purpose of the computations, carried out at the request of the Bureau of Ordnance, Department of the Navy, was the prediction of the performance of explosives of various chemical compositions. In the course of the work, tables and graphs of certain functions that facilitated the solution were also prepared.

The Johns Hopkins University has been engaged in a study undertaken for the Department of the Army to determine the physiological effects of exposure to nuclear radiation. The results are to be used to set safety limits and dosages to which workers and military personnel may be exposed. Because of the obvious difficulty of experimenting with human beings, experimental material obtained from test animals has been used. In connection with this work, the NBS Computation Laboratory was asked to compute the life expectancies for animals subjected to various dosages of different types of radiations and to compare them statistically with the normal life expectancies of unexposed animals. Theories regarding ionization of body tissues caused by radiation were also evaluated numerically at the Laboratory, and the results were compared statistically with experimental results.

An outstanding example of the application of computing techniques to the science of management is found in a problem now in process of solution for the Air Comptroller's Office. The object of the problem is to devise a purely mechanical process that will replace the thousands of individual human decisions involved in a major management program. For example, in achieving a given volume of production or in deploying a certain number of troops and equipment at a given date, it is necessary to procure machines, transportation, materials and supplies, spare parts, and fuel and to provide for the training of operating and supervisory personnel. The required levels of activity involved at each step have hitherto been the subject of a multitude of separate decisions arrived at by "educated guessing" on the part of different individuals. The present project aims to develop methods of replacing these decisions by high-speed mathematical computation. Methods are being tried out with the most up-to-date computing equipment available, and further methods will be tested as better and faster computing machines become available in the future.

Assistance is also being furnished to the Central Radio Propagation Laboratory of the National Bureau of Standards in its study of the effect of ionospheric conditions on radio transmission. First, data recorded in millions of observations, which are being made hourly over a period of years by stations all over the world, are transcribed onto punched cards. Then the material is analyzed statistically, by punched-card machine methods, to determine the effects of the hour of the day, season, and geographic location, and to correlate these effects with a number of outside factors suspected of influencing them.

Another field in which high-speed computing is expected to play an important part is meteorology. The Computation Laboratory has assisted in computations needed for objective analysis of meteorological elements. This work, requested by the meteorological project at New York University, included determination of the least squares solutions for divergence, wind

velocity, barometric pressure, and other quantities on the basis of data collected from weather stations throughout the Eastern United States.

For a number of years, the Computation Laboratory has been the chief producer of Loran navigation tables. These tables, prepared at the request of the Navy's Hydrographic Office, are being used in increasing numbers in air and sea navigation.

Other recent computing projects include the analysis of the effect of gusts on airplanes in supersonic flight; the calculation of data required in naval architecture, such as the wave resistance of ships; analysis of the crystal structure of cement compounds and the solution of other problems in molecular structure; and the mathematical tracing of light rays through lens systems.

In general, the tables prepared by the Computation Laboratory are of a type essential in the solution of problems in such fields as atomic energy, aerodynamics, radio and radar navigation, and military ordnance. To date, considerable work has been done on the tabulation of the Jacobi elliptic functions, gamma functions for complex arguments, and spheroidal wave functions.

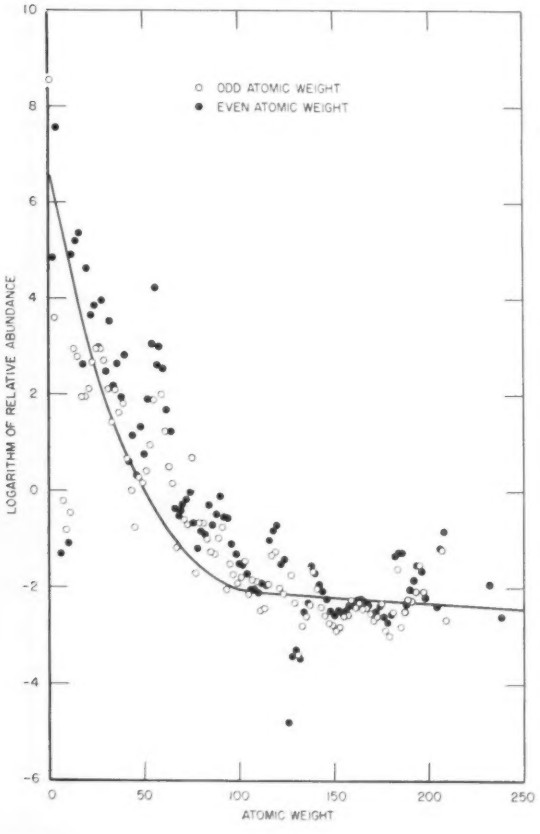
Of considerable importance to workers in nuclear physics are the tables of Coulomb wave functions. These tables, soon to be published, will tabulate the solutions of an important differential equation that arises in the quantum mechanical treatment of two particles moving in a Coulomb field of force, particularly in problems of proton-proton and proton-neutron interaction. A compilation of tables for use in the analysis of beta-spectra is now in press.

The recently completed tables of confluent hypergeometric functions and related functions have important applications in agricultural statistics and quality control, where they are used in analysis-of-variance tests and sequential *t*-tests. A need for such tables arose during the war, in connection with ammunition performance tests and similar problems of acceptance sampling.

Another recent table, which gives scattering functions for spherical particles, was the direct outgrowth of a series of investigations relating to problems in chemical warfare. These tables are used for such purposes as determining the size and concentration of particles in suspension from measurements of the attenuation of light beams.

Tables of spheroidal wave functions are now being prepared. These functions, which are solutions of the wave equation in prolate and oblate spheroidal coordinates, are of broad utility. Problems involving the radiation and scattering of waves from strips or disks or material and from wires of finite length, all require a knowledge of the mathematical properties and the numerical values of solutions of the wave equation for these coordinate systems. The solutions are likewise required in studying the diffraction of waves through slits and circular openings, the absorption of sound by strips or by circular patches of material, and the behavior of electrons in diatomic molecules.

In the future, it may be expected that the program of the Computation Laboratory will tend to place less emphasis on the preparation of new basic tables and to give more attention to the solution of problems in physics and engineering whose treatment with desk calculators would be an insurmountable task. A large proportion of the time of the staff will thus be spent in preparing problems in such form that they can be handled by the new high-speed electronic computers. However, it seems likely that mathematically trained human operators equipped with desk calculators will always be required to perform computations that are either too small for high-speed calculators or that require a degree of intelligence not yet incorporated into the design of electronic computers.



This theoretical curve for the relative abundance of the elements was recently computed on SEAC by the NBS Computation Laboratory for the Applied Physics Laboratory of the Johns Hopkins University. The calculated curve, a preliminary result based on the neutron capture theory of element formation in the expanding universe, was obtained as a result of the solution of a system of 28 first-order nonlinear differential equations. The curve is compared with the observed distribution of the elements as shown by the plotted points.

Portable Abrasion Tester

A portable, yet highly dependable, device for testing the abrasion resistance of floor surfaces has recently been developed by D. W. Kessler, of the National Bureau of Standards, with the cooperation of W. C. Clark, of the General Services Administration. By providing a simple, convenient method of testing each floor tile before it is laid, this field abrasion tester has successfully provided the long sought means of preventing unequal wear of floor surfaces in Government buildings. Difficulty in the past has grown out of the fact that floor tiles exposed to severe traffic must have approximately the same abrasion resistance; otherwise the floor surface will become uneven with time. Moreover, the device is also proving useful in the development of better purchase specifications for natural corundum; this is possible because corundum grains rather than an abrasive wheel is utilized in the tester.

The tester was developed at the Bureau following a requests from the General Services Administration for a testing apparatus whose results would correlate with service wear from heavy traffic. It consists essentially of a notched steel wheel mounted on an overhanging frame, so that a definite and constant weight will bear upon the specimen as the wheel is turned. The tester was designed to provide for a steady flow of No. 60 artificial corundum between the steel wheel and the specimen that is mounted on an incline; this feature of steady flow of abrasive grain accounts for the dependability of the method. (An earlier version utilizing an abrasive wheel was discarded when it was found that nonuniform abrasion was obtained at the wheel's edge due to clogging and dulling of abrasive grains.) Though of sturdy design, the tester is light enough to be moved easily and set up near the stock pile of tiles. It is composed mainly of wood except for the abrading wheel and its carriage.

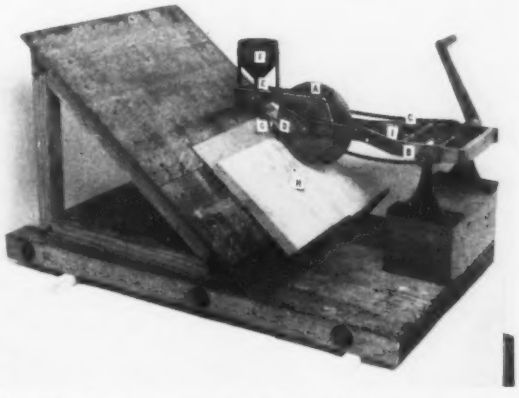
In making a test the steel wheel is turned 25 revolutions (in approximately 1 minute), thus cutting a circular segment in the specimen. The length of this segment is measured to a tenth of a millimeter and the segment area computed; this value indicates the abrasive resistance of the material. Results obtained with the tester are in good agreement with those provided by the conventional NBS laboratory apparatus (BSJ Research **11**, 635 (1933), RP612; also NBS Building Materials and Structures Report, BMS98). The correlation coefficient of this laboratory apparatus with actual wear is 0.99 where perfect correlation is 1.00.

The field abrasion tester was first applied in evaluating the floor tiles used in the Mint buildings at Denver and San Francisco. It has also been utilized by the Public Buildings Administration for selecting material to be used in several other buildings.

More recently, when the Bureau was requested by the Federal Supply Service and the Munitions Board to assist in the preparation of a more reliable purchase specification for corundum, the new field abrasion tester seemed to offer a means of comparing different samples. As natural corundum is purchased from various sources, a dependable control on its quality is necessary. Experiments made with the tester by using the samples of corundum to abrade standard samples of glass revealed wide variations in corundum from different sources. Since the corundum samples are often contaminated with gangue materials that are less abrasive than the corundum, the test was found to be sufficiently sensitive to show such effects quickly. It is possible with the tester to determine not only the abrasive quality of the material, but also its breaking-down characteristics. Because the grains of an abrasive break into smaller particles during use, the grinding rate is reduced. Thus, by repeating the test 10 times with the same portion of sample, a measure of the breakdown rate can easily be obtained.

Corundum is used for various purposes, including the grinding of lenses and for snagging wheels. Artificial corundum is superior in abrading value and can be obtained in uniformly high purity. However there seems to be a distinct advantage in natural corundum for lens grinding because of the way the particles break up. It is claimed that the natural products breaks into cubical particles, whereas the artificial forms splintery shapes. The latter produces deeper cuts in the glass, while the cubical shapes produce a more uniform surface.

Supplementing the work at the National Bureau of Standards, the U. S. Bureau of Mines has devised a means of analyzing corundum for impurities. Solution of the impurities, flotation, and microscopic determinations are employed. These methods, together with requirements for abrasive values and breakdown rates as worked out by the National Bureau of Standards, have been incorporated in a new specification for corundum.



Portable abrasion tester for determining wear resistance of floor tiles at the building site. (A) Abrading wheel; (B) framework; (C) sprocket drive; (D) abrasive feeder drive belt; (E) rubber belt conveyor for abrasive; (F) funnel for abrasive; (G) trough conveyor for abrasive; (H) tile being tested; and (I) adjustment weight.

Radon Measurement

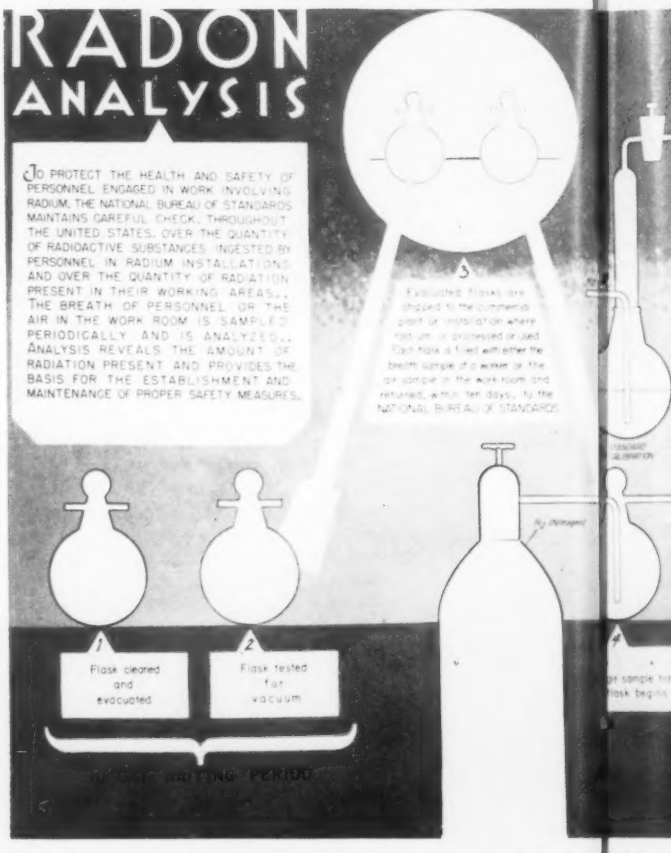
To protect the health and safety of personnel engaged in work involving the handling or processing of radium, the National Bureau of Standards maintains careful check, throughout the United States, over the quantity of radium ingested by such personnel and over the quantity of radon present in their working areas. The breath of these workers, or the air in the work room, is sampled periodically and is measured for its content of radon—the gas produced by radioactive disintegration of radium. This analysis reveals the amount of radioactivity present and provides the basis for the establishment and maintenance of proper safety measures.

The radon testing program was first inaugurated in 1941 when the Surgeon General's Office requested the Bureau to establish a program designed to prevent injury or death to personnel working with radium. With the use of highly specialized electronic equipment and ionization chambers that are continuously monitored by the national standards of radioactivity, the Radon Testing Laboratory has developed a method for measuring radon of very low concentration to a high degree of precision. As a result of the cooperative efforts of the Bureau and the officials and hygienists responsible for the protection of the workers from unsealed radium, deaths and injury from radium poisoning such as occurred in the years following the first World war are now being prevented.

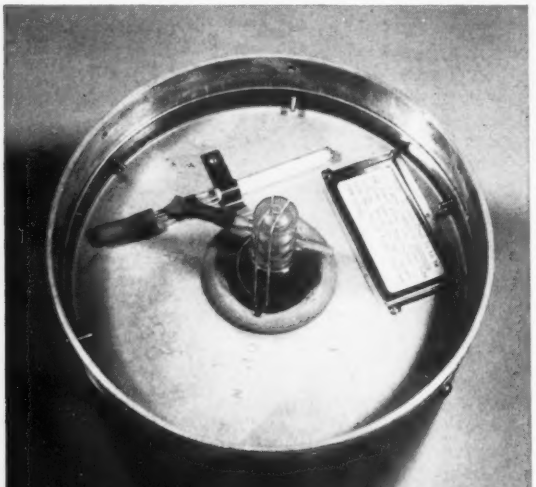
Radon Testing and Health Physics

Radon determination makes possible the rapid evaluation of the radon content of air in work and storage rooms, radium processing plants, and mine areas. Radon measurements can thus be used to determine whether the maximum permissible dosage limits are being exceeded or whether sufficient ventilation has been provided. In the case of personnel engaged in the handling or processing of radium, radon measurements of breath samples give an indication of the amount of radium ingested, either by inhaling airborne particles or transfer of contamination from the hands to the mouth.

Samples for radon determination are submitted periodically by both private and Government agencies. The majority of the Government agencies have a health physics division within the agency that specifies the maximum permissible limits (certain maximum values for some types of radiation are recommended by the National Committee on Radiation Protection; other



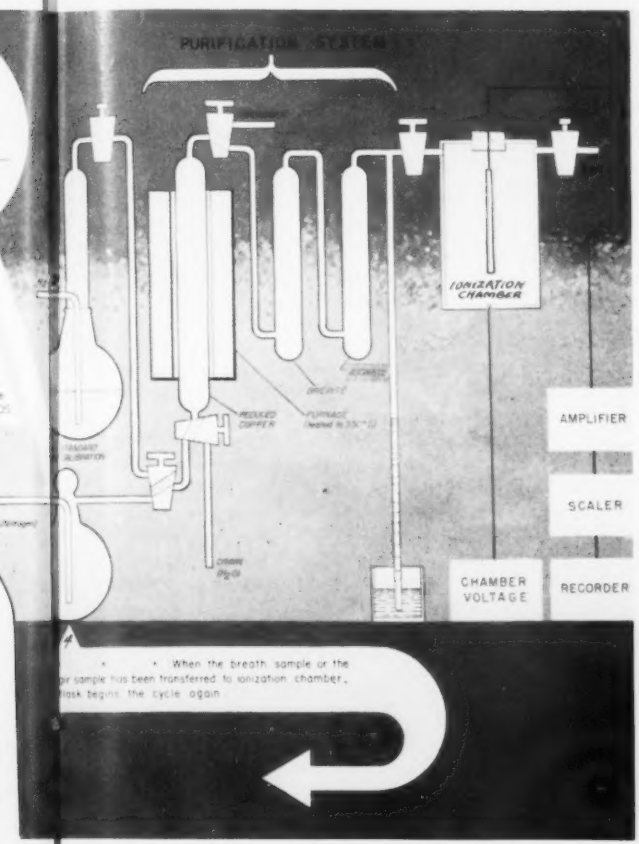
Flow chart for the radon testing program maintained at the National Bur personnel engaged in work involving the handling or processi radium from the Bureau to radium installations (3) throughout the , the h sampled periodically. In the radon laboratory at the Bureau samples through a purification system and carefully analyzed for their on conte active substances ingested by the workers or the ee of r



All breath or workroom air samples are collected in two-liter capacity Pyrex flasks. The sampling flasks are evacuated by the Bureau, packed with foam rubber in aluminum shipping containers, and shipped to the radium installations.

Samples for radon determination are submitted periodically by both private and Government agencies. The majority of the Government agencies have a health physics division within the agency that specifies the maximum permissible limits (certain maximum values for some types of radiation are recommended by the National Committee on Radiation Protection; other

rement and Control



the National Bureau of Standards to protect the health and safety of ocessing radium. By means of special evacuated flasks (1, 2) shipped t the ..., the breath of these workers or the air in the workroom is reau samples are transferred to evacuated ionization chambers (4) r their radon content, thus providing a measure of the amount of radio- or the ree of radioactive contamination of working areas.

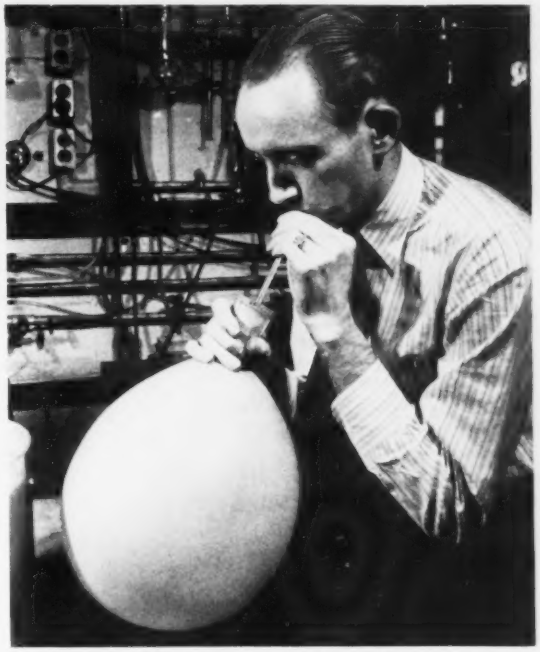
values have not yet been definitely filed) of radon and investigates the cause of excessive values when such are indicated by the Bureau's reports. For private organizations, the state health department performs this function. Still other large agencies maintain their own health office or hygienist. Other installations, such as uranium mines, are under surveillance of the U. S. Public Health Service, Federal Security Agency, working in conjunction with certain state health departments.

In addition to the provision for periodic tests, sampling flasks and stand-by equipment must always be kept ready for emergencies, such as the accidental spilling of radium or the failure of automatic devices for the remote control of measuring equipment and of hospital equipment. When such accidents occur, samples of room air, as well as expired air samples from personnel exposed to the damaged material, are collected and submitted to the Bureau for radon determination. Samples taken soon after the accident give an indication of the extent of the danger, whereas follow-up samples show the efficiency of whatever decontamination procedures have been used and possibility of permanent injury to employees.

For the sake of complete uniformity, sampling flasks for the collection of all air samples are supplied by the National Bureau of Standards. These Pyrex flasks, of 2-liter capacity, are evacuated in the laboratory and sent out, upon request, packed with foam rubber in aluminum shipping containers. After being filled with room or mine air or exhaled air, the flasks are returned to the Bureau for determination of radon content. Work-room air samples are collected by opening the stopcocks on the evacuated flask so that the air flows in through a filter. Breath samples are obtained by transferring exhaled air from previously inflated balloons into the evacuated flask through its stopcock.

The samples, especially those of breath, must be sent to the Bureau immediately, because measurements on weak radioactive air (such as the average breath sample) must be made within 10 days of the collection date. Radon has a half-life of slightly less than 4 days, and detection is very difficult after more than 10 days have passed.

Once received, the air samples are transferred to evacuated ionization chambers through a purification



The quantity of radium ingested by workers is indicated by the amount of radon in their exhaled breath. A sample of the worker's breath to be analyzed at the Bureau is obtained by the inflation of a balloon as illustrated here.

A sample of breath submitted by a manufacturer of radium-painted dials is being drawn off from a sampling flask (lower center). After introduction into the ionization chamber (lower right), the radon content of the sample is measured by a count of the alpha particles that are emitted in the process of the disintegration of radon.

system that consists of a tube of reduced copper heated to 500° C to remove oxygen, calcium chloride to take out water vapor, and ascarite to remove possible acid vapors and carbon dioxide. Between components of the system, and near the entrance tube of the chamber, there are filters of Pyrex wool to prevent the transfer of solid matter. As the volume of an ionization chamber is approximately twice that of a sampling flask, the air in the latter can be flushed out by a stream of pure nitrogen. To obtain maximum efficiency of the purifying system the rate of flow is controlled at approximately 400 milliliters per minute. In addition to the ionization chambers and the purifying system, the equipment includes an amplifier, scaling circuit, and automatic recorder.

The ionization chambers are brass cylinders having walls 0.25 inch thick and removable bottoms secured with screws. A thin annealed copper gasket is used to maintain a vacuum while the system is being either flushed or checked for leakage and while the chamber is being prepared for filling. The heavy walls permit resurfacing from time to time when contamination becomes sufficient to interfere with normal counting rates. The collecting rod is introduced through a Teflon insulator in the top of the chamber, where O-ring gaskets maintain a vacuum tight joint. The chamber proper is maintained at approximately 1,000 volts, whereas the collecting rod is attached directly to the grid of the first tube of the amplifier which, in the latest design, is mounted directly above each chamber. The entire chamber is enclosed in an insulated shield that is at ground potential. The joints of the chambers must be tight for the above reasons as well as to prevent diffusion of any air into the chambers during the period of measurement. The presence of even a fraction of a percent of oxygen will reduce the mobility of electrons and thus reduce the efficiency of counting.

For each alpha particle emitted in the disintegration of radon, a cloud of ions and electrons is formed; the electrons possessing high mobility are swept to the central electrode, where they produce electronic pulses. (F. J. Davis, J. Assoc. Official Agr. Chem. **28**, 682 1945.) These pulses are amplified 10,000 to 20,000 times and then fed into a scaler, which puts out 1 electrical pulse for each 64 pulses fed into it. These output pulses actuate a traffic recorder that prints the day of the week, time of day, and the accumulated scale count each hour. This makes it possible to utilize the normal working day for computation of previous records, flushing, testing, and refilling the ionization chambers, while the actual measurements can be made during the night. The method allows arbitrary selection of the period of measurement in order to permit decay of short-lived alpha emitters that may have been transferred into the chamber. It also permits RaA and RaC to grow to approximate equilibrium.

The chambers are calibrated periodically with radon emitted by a standard solution containing 10^{-9} gram of radium. The calibration is determined in number of counts recorded per unit (Curie) of radon. The mathematics involved in the final evaluation of the records, as well as other detailed information on the apparatus and procedure, are given in a paper by Leon F. Curtiss and Francis J. Davis (J. Research NBS **43**, 181 (1943) RP1557). A summary of observations that were made during the first few years of operation of the present type of equipment is given in a report by F. J. Davis (J. Research NBS **39**, 545 (1947) RP1846).

Radium Assays by the Radon Method

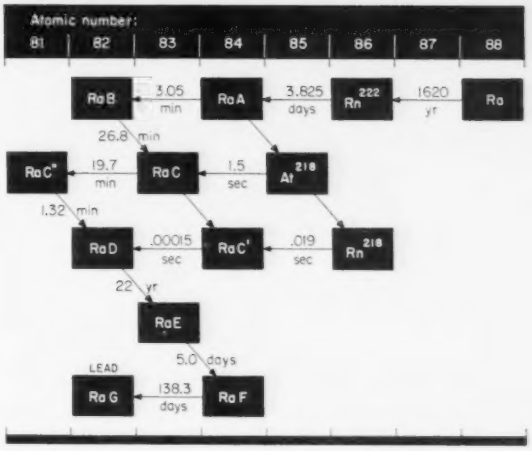
More recently, the National Bureau of Standards has expanded the scope of its radon program to include the determination of radon content of water samples from lakes, rivers, and wells, particularly those subjected to naturally occurring radioactive deposits or waste from radium processing plants. Tests are also made of the air from mines where uranium and its associated products are being extracted or where there is a possibility that these substances may occur in conjunction with other mined ores.

The amount of elemental radium present in any ore, rock, or other solid material in amounts as low as 10^{-12} gram per gram of material may be measured by the NBS radon method, which can distinguish radium from other radioactive elements, such as mesothorium or uranium. This distinction is possible because other gaseous alpha emitters such as thoron (which might be present) are relatively short-lived as compared to radon. Thus, if several hours are allowed for their decay after transfer to the chambers, only those counts due to radon and its decay products, plus those of the chamber background, will be recorded.

Radioactive solids may be handled in one of two ways. They are either subjected to sufficient heat in a fusion furnace to force the radon into an evacuated ionization chamber or are put into solution chemically, after which the process is the same as that employed in assaying water samples. The latter procedure has proved to be the more efficient and reliable and is now used exclusively in the Bureau's laboratory. Thus all assays are handled as liquids.

Removal of radon from liquids is accomplished by refluxing in the presence of pure nitrogen, which is bubbled through the solution during boiling. After sufficient time has elapsed for a measurable amount of radon to have collected, the gas is transferred to previously evacuated chambers through the purification system. Here the ascarite trap plays an important role in removing any acid vapors that may come from the boiling liquid. Whereas weak radioactive water or solutions require a collection period of from 10 to 15 days, 24 hours is sufficient for some ores and concentrates in solution. The maximum amount of radon from any given solution will have collected in approximately 30 days when a state of equilibrium has been reached.

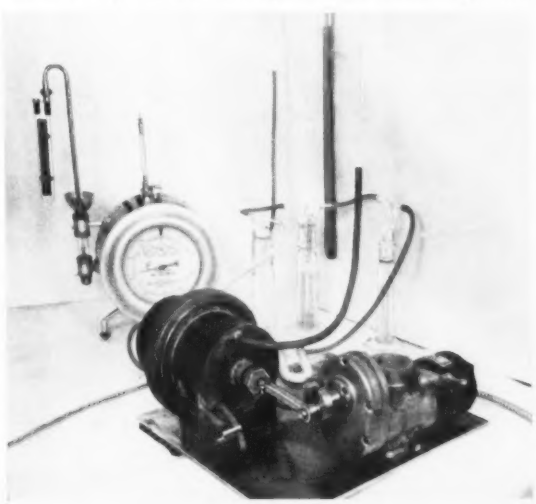
The radon method is most useful when the radium content of the samples is less than 10^{-7} gram per gram of solid material or per liter of liquid. When the concentration of radium in samples is as low as this, ordinary methods of assaying are not sensitive enough, and assaying involves the national standards of measurement, as well as rigorous control over the analysis process if adequate precision in the results is to be obtained.



Exact disintegration scheme of the radium series. Those elements from which the arrows point horizontally to the left emit alpha particles. Thus alpha ionization chambers used at NBS measures the amount of radon gas that has been previously given off by radium ingested in a worker's body or present in his work room. If sufficient time is permitted for approximate equilibrium to be reached before measurement is started, the alpha particle counting rate recorded will be directly proportional to the quantity of radium originally present in the worker or his work area. The chambers as used are not sensitive to beta rays, which are indicated by arrows pointing down and to the right. The final or end product of the series is lead, which is stable.

Water Vapor Permeability of Leather

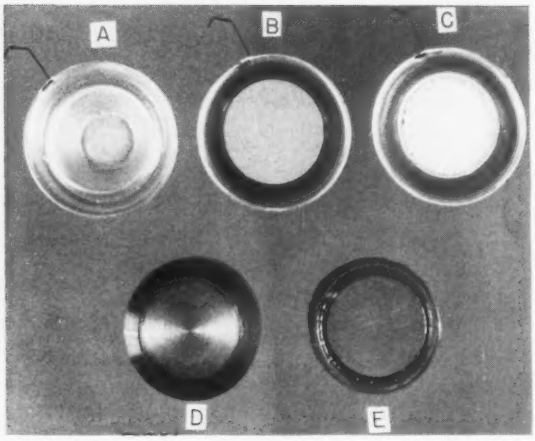
Chemists at the National Bureau of Standards are studying the mechanism of water vapor transmission through leather with the ultimate aim of discovering a material for shoes that will be highly permeable to water vapor but not to liquid water. One phase of the project, under the direction of J. R. Kanagy and R. A. Vickers, III, was the development and standardization of a more suitable method for measuring water vapor permeability.



The ability to transmit water vapor is one of the important properties of leather that make it desirable for use in the construction of shoes. Comfort and foot health are dependent upon the elimination of perspiration that accumulates in the shoe. A knowledge of the factors involved in water vapor transmission is important in the proper selection and manufacture of materials that will give improved service and yet maintain a sufficiently high level of permeability to assure comfort to the wearer.

The water vapor permeability of leather is inherently high. However, the use of fats and greases to improve water resistance of shoe leather may lower water vapor transmission so much that the shoe uppers cannot transpire perspiration as fast as it is formed.

This apparatus determines the amount of water vapor that will pass through a leather sample in a given length of time. The chamber in the center foreground holds a leather diaphragm under the knurled ring. The plunger extending from the right end of the chamber is connected to the diaphragm and to the cam on the transmission at the right. As the equipment flexes the leather, to simulate the action of shoe leather while being worn, moist air is pumped into the right half of the chamber and dry air into the left. The moisture that penetrates the leather is carried out of the chamber and through a tube containing calcium chloride.



This cell is used for the determination of the water-vapor permeability of leather. The photograph shows an empty aluminum cell (A), a filled cell covered by a leather sample (B), the drying agent in the cell (C), a copper template used in sealing the cell (D), and a leather sample that has been used in an experiment (E).

The method used at the Bureau is a modification of the approved procedure of the American Leather Chemists Association. Tests are made with a water vapor permeability cell, devised at the Bureau. The housing of the cell is a circular aluminum cup with a flange. The total diameter is about 4 inches. The flange is bent in such a way that a raised rim is formed at the edge of the cup upon which the leather fits tightly. In preparing the cell the cup is filled with the desiccant ($CaCl_2$), and the leather specimen, larger in diameter than the cup (but smaller than the flange), is placed over the rim. A circular copper template, one surface of which is machined to the same diameter as the cup, is then fitted as nearly as possible directly over the cup. Molten microcrystalline wax is poured around the groove formed by the template and the flange. This seals the edge of the leather and fastens it to the cell. After the wax has hardened, the copper template is removed, leaving an area of approximately 25 square centimeters of the leather exposed.

The completed cell is hung in a cabinet maintained at the desired relative humidity and temperature. A special mechanism allows the cell to be weighed at definite intervals without removal from the cabinet. The slope of the resulting curve, indicating the increase in weight of the cell with time, gives the water vapor permeability of the sample in grams per second per square centimeter of the exposed area.

With the new method a test may be completed in 6 hours, whereas with the present adopted procedure, four to five days are required. The cells for the new procedure may be prepared in 2 minutes; the A. L. C. procedure requires 15 minutes. Greater accuracy is obtained with the new method since the weighings are made without touching the specimens. The new cell is made of aluminum and is, therefore, unbreakable. Time for disassembling and cleaning off old wax is also reduced to a minimum with the new type of cell.

From the results of the investigation, it was found that the water vapor permeability of leather depends upon a number of factors, including thickness of sample, grease content, and the relative humidity and temperature of the atmosphere. It is greatly reduced by the presence of the natural glyceride greases. The grain layer of the leather is the first stratum to become saturated with grease. When this occurs the leather becomes almost completely impermeable to water vapor. There is no good correlation between water vapor permeability and air permeability.

In order to determine if leathers treated with water-repellent materials other than the glyceride greases might have higher water vapor permeabilities, studies were made with sulfonated oils, rubber, and acrylate resin. The results show that these materials decrease water vapor permeability in the following order of increasing magnitude: Sulfonated oils, acrylate resins, rubber, and finally the glyceride greases. The comparatively high water vapor permeability of the leathers treated with sulfonated oils and acrylate resins is attributed to the influence of the polar groups in these impregnants.

A method for determining water vapor permeability during flexing was also developed. This is of interest because it simulates more closely actual service conditions. These studies indicate that flexing of the specimen has no influence on the water vapor permeability of degreased leathers; however, for leathers that contain grease, there is an increase in water vapor permeability on flexing.

The experiments on the mechanism of water vapor transmission indicate that in addition to gaseous diffusion moisture penetrates leather by conduction over the surface or by some form of activated diffusion.

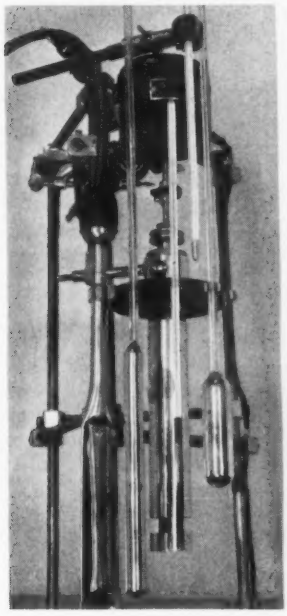
For further technical details, see Factors affecting the water-vapor permeability of leather, *by Joseph R. Kanagy and Robert A. Vickers, III. J. Research NBS* **44**, *347 (1950) RP2082.*

Volume Dilatometry

Scientists of the National Bureau of Standards have found the simple, inexpensive volume dilatometer to be a valuable research tool, not only for obtaining data on volume coefficients of thermal expansion, but also for studying phase changes in solids and liquids. Continued application of volume dilatometry at the Bureau over the past 15 years has resulted in improvements in technique and in simplification of the apparatus to such an extent that accurate dilatometers can now be made and used in almost any small laboratory.

Linear dilatometers of various types have frequently been used to advantage in determining the expansivity of metals and other solid materials. They cannot, of course, give correct results for liquids or for other

This volume dilatometer provides a dependable instrument for obtaining data on volume coefficients of thermal expansion and for studying phase changes in solids and liquids. In the photograph (left) are shown (left to right) a knifeblade heating element, a dilatometer, a stirring device, a thermometer to record the bath temperature, and air thermometer to record the dilatometer stem temperatures, and a second dilatometer. (Center), the apparatus is being used to make a measurement; in the left foreground is an electronic thermal regulator incorporating a thyratron relay. The diagram (right) illustrates consecutive steps in the construction and filling of the dilatometer.



fluid materials. In these cases the volume dilatometer can be used successfully; it has been shown to have a precision of about 1 percent.

Primarily, the volume dilatometer measures the change of volume of a sample as it undergoes a change in temperature. Its secondary importance lies in the discovery of phase-changes and other transitions. Thus, if the density or volume of a substance is plotted as a function of the temperature, there will be anomalies in the otherwise smooth curve wherever there is a change of phase, or other transition. These anomalies represent points at which a change occurs in the structure of the sample or in the types of motion by which it can absorb energy. They may or may not be accompanied by the release or absorption of heat.

Materials for the construction of the instrument consist of glass tubing of any convenient size and a calibrated glass capillary. The confining liquid may be mercury or any other substance that has a known expansivity and that will not react with the sample. Uniform heating is provided by means of a bath containing alcohol, water, or a high-boiling oil, depending on the range of temperature to be studied.

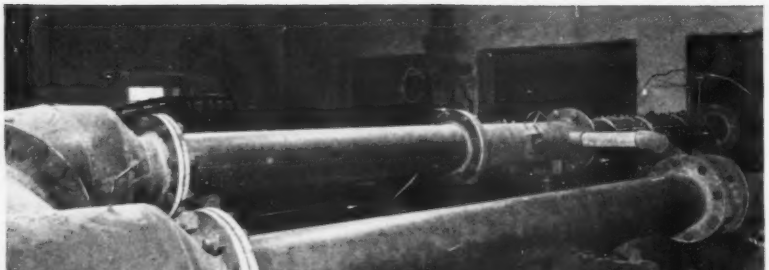
The preparation and operation of the volume dilatometer may be described briefly as follows: A glass capillary is carefully calibrated and sealed to one end of a larger glass tube. The weighed sample is introduced into the tube, a glass bulb is added, and the tube is sealed. The bulb is used to prevent overheating of the sample during the sealing operation. The dilatometer is then weighed, evacuated, filled with mercury, reweighed, and then placed in a bath. As the bath is heated, the sample expands, forcing mercury up into the capillary where readings may be made. From the known weights and densities of the sample and the confining liquid and from the known expensivity of the confining liquid, the expansivity of the sample can be calculated.

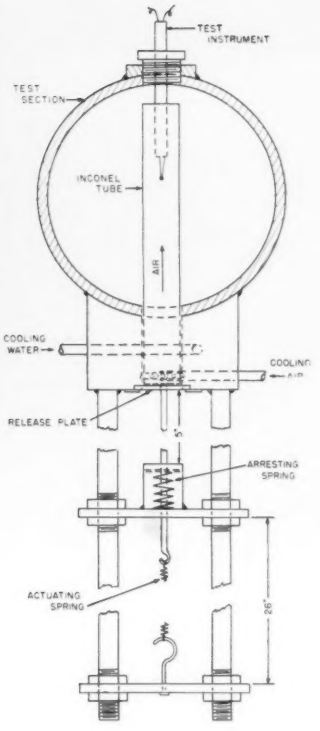
For further technical details, see Volume dilatometry, *by Norman Bekkedahl, J. Research NBS* **43,** *145 (1949) RP2016.*

Bibliography of Electron Microscopy

A new compilation of technical literature on electron microscopy, recently issued by the National Bureau of Standards, consists of scientific papers published prior to 1950. The titles of the publications have been grouped in the following broad categories: Books, survey articles, instrumentation, electron optics, related instruments, and applications. A special author index refers to the consecutively numbered references.

Circular 502, *Bibliography of electron microscopy*, 87 pages, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 25 cents a copy.





Apparatus for Studying Temperature-Sensing Devices in Jet Engines

Efficient operation and adequate protection of the power plant in jet engines requires very rapid reduction in the temperature of the gas stream whenever this temperature exceeds a limiting safe value. The rates of response of whatever temperature-sensing devices are used thus assume considerable importance in jet-engine operation. Various methods for determining response rates have been worked out, but in most cases they have proved unsatisfactory because they failed to simulate operating conditions adequately.

Recently, A. I. Dahl and E. F. Fiock of the Bureau's combustion laboratory have developed apparatus that determines the rate of response of jet-engine temperature elements under conditions very closely approximating those obtaining in the combusion stream. With this equipment, response times as short as 0.02 second have been measured for a wide variety of thermocouples, resistance thermometers, and thermistors.

The rate of response, or "characteristic time", of a specific temperature element (defined as the time required by the element to undergo 63.2 percent of the total change in temperature to which it is subjected) depends on its mass, surface area, and heat capacity, and on the rate at which heat is transferred to the element from the gases flowing through the engine. Thus, in any test system in which heat is transferred to the temperature element mainly by radiation or natural convection, the observed values would not be applicable to jet engines. The Bureau therefore developed a system for studying characteristic times in which heat is transferred primarily by forced convection, as actually occurs in engines.

This apparatus consists essentially of a jet-engine combustor, or burner, with provision for mounting instruments in the exhaust gas stream and a device for producing rapid changes in the temperature of the mounted test instrument. A compressor, or blower, supplies air to a single Jumo 004 turbo-jet engine combustor equipped with its normal fuel injector and spark plug. Exhaust gases from the combustor pass through two 90-degree turns, through a perforated plate, and then through about 10 feet of straight pipe before reaching the test section, which has three convenience hatches for mounting instruments. In this way, the gas stream is kept at essentially uniform temperature and velocity over the central half diameter of the test sec-

Above: A portion of the jet burner system (left) used to study the response rates of temperature-sensing devices for jet engines. Thermocouples mounted in the gas stream for study can be seen at the extreme right end of the straight, horizontal pipe in the background. Right: Apparatus developed at the Bureau for rapidly changing the temperature of the gas surrounding a jet-engine temperature-sensing element. The test instrument projects vertically downward into the test section of the jet burner system but is shielded from the heated gases by means of the Inconel tube, through which a stream of cold air is forced upward. When the release plate supporting the tube is displaced, the spring at the bottom of the apparatus suddenly removes the tube, exposing the instrument to the hot gases in the test section almost instantaneously.

tion, and exposure of any instrument to direct radiation from the flame is prevented.

The gas temperature and flow rate at the combustor outlet are controlled by means of a valve at the inlet to the compressor and by adjusting the fuel pressure. A bleed line containing a butterfly valve also provides an auxiliary control of the flow in the test section, independent of the operating conditions of the burner. Pressures observed with a pitot-static tube, together with the known value of gas temperature, permit calculation of the mass flow rate in the test section.

For measuring rate of response, the temperature of the gas surrounding the test instrument must be changed very suddenly. This cannot be accomplished with sufficient rapidity by controlling the combustor. Apparatus was therefore developed for quickly immersing the instrument without altering the steady flow of exhaust gas in the test section. In this device, an Inconel tube, projecting vertically upward through the test section and held in position around the test instrument by a release plate, provides a flow channel for cold air. When the release plate is pulled out of the way, a spring suddenly removes the tube, exposing the instrument to the hot gas of the main stream almost instantaneously. During the downward movement of the tube, the supply of cold air is stopped automatically. In this way a test instrument at a known, moderate temperature (controlled by the air rate through the Inconel tube) can be brought in contact with exhaust gas at any given temperature and at any mass flow rate within the capacity of the system.

Two systems of this kind are now in operation at the Bureau. Air for one is supplied by a blower with a capacity of 4,000 cubic feet of free air a minute, and air for the other is provided by centrifugal compressors having a combined capacity of 10,000 cubic feet per minute. The systems have identical Inconel test sections, about 6 inches in diameter. The second system can be operated at temperatures up to about 2,000° F. and at mass flow rates up to 15 pounds per square foot per second in the 6-inch test section. A test section 3 inches in diameter is used in research where velocities up to 1,800 feet per second are of interest.

The apparatus has been used at the Bureau to study the performance of temperature-sensing elements exposed directly to the gas stream, elements encased in metal and ceramic protection tubes, and elements imbedded in insulating materials, such as quartz and beryllia. Although the equipment was designed primarily to subject the test junction to a sudden increase in temperature, characteristic times for the cooling process have also been obtained. This was done by heating the test junction electrically while it was surrounded by the Inconel tube, then subjecting it to a stream of unheated air. Results were found to agree with the theory that applies for heat transfer by forced convection; that is, the characteristic time at a given mass flow rate was the same, whether the instrument was heated or cooled.

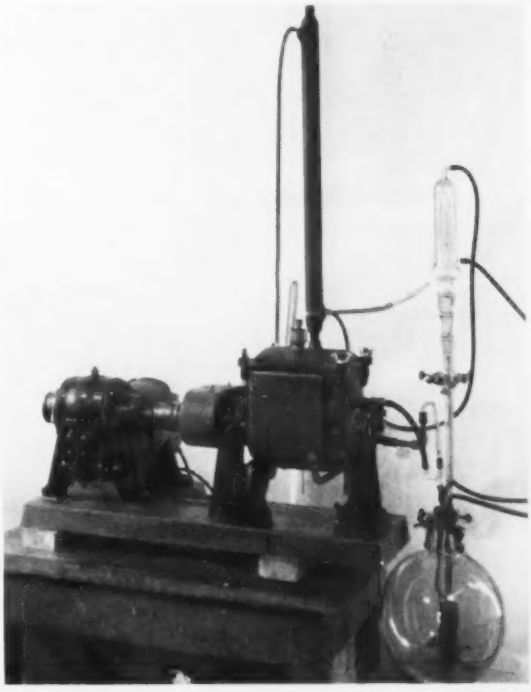
For further technical details, see Response characteristics of temperature-sensing elements for use in the control of jet engines, *by Andrew I. Dahl and Ernest F. Fiock, J. Research NBS* **45**, *292 (1950) RP2136.*

Rapid Extraction of Resins From Wild Rubbers

Chemists of the National Bureau of Standards have developed a simple method for converting wild rubbers having a high resin content into a product comparable to plantation rubber. This is accomplished by extracting a large portion of the natural resins from the wild rubbers.

The deresination studies were conducted by J. W. Wood and Rachel J. Fanning of the Bureau's rubber laboratory as part of a research and testing program on natural rubbers sponsored by the Rubber Development Corporation of the Reconstruction Finance Corporation. Two Mexican wild rubbers obtained from the shrubs of Chilte and Guayule were chosen for the investigation.

Although synthetic rubber can be substituted for natural in the manufacture of many rubber products, and is actually superior for some of these uses, there



This extraction apparatus is used to convert wild rubbers having a high resin content into a product that compares favorably with the plantation rubber. The sample in the chamber (center) is masticated by motor-driven blades while acetone is passed through it from the glass distilling apparatus at the right. Steam passed through the coil in the balloon flask vaporizes the acetone.

are still other products that can be made only from natural rubber. This is true for many materials used by the armed forces. It was therefore necessary during World War II, when about 95 percent of the world's supply of natural rubber was cut off, to make use of every bit of available natural rubber, whether it was of good or inferior quality. Many types of wild rubbers were collected from tropical America and Africa. Some were of such inferior quality that they had to be blended with better grades of rubber before they could be used. Others could be improved in quality by the extraction of their resins, which would give the resulting rubber a higher percentage of rubber hydrocarbon.

For experimental extraction of resins from the wild rubber, the Bureau's chemists used a modification of a commercial solvent-tight mixer, designed for compounding heavy industrial pastes. Two S-shaped stainless-steel blades, operating within the extraction chamber, were rotated while solvent was passed into the chamber from a glass distilling apparatus. The same apparatus was also operated in another set of experiments without the blades rotating in order to compare the rubbers made both with and without mastication.

The Chilte rubber, which originally contained over 50 percent of resinous material, required only 4 hours of extraction when accompanied by mastication in order to reduce the resin content to that customarily found in plantation rubber of high quality. Even less time was required to reduce the 20-percent original resin content of the Guayule to a comparable figure. Without the mastication the extraction process required more than 12 hours to bring about similar reductions in the acetone-soluble material.

The tensile strengths of vulcanizates prepared from both types of rubber increased as greater amounts of acetone-soluble material were removed. The tensile strength of the rubbers produced by the mastication process were greater than those of the rubbers prepared when no mastication was used. It was concluded from this investigation, therefore, that wild rubbers containing high percentages of acetone-soluble materials can be deresinated efficiently if mastication of the rubber takes place during extraction, and that the quality of the resulting rubber is greatly improved by the process.

Further technical details will be published in a forthcoming issue of the Rubber Age, 250 West 57 Street, New York, N. Y.

Mr. Wood is now associated with the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Center, Beltsville, Maryland.

Publications of the National Bureau of Standards

Periodicals

Journal of Research of the National Bureau of Standards, volume **45**, number 4, October 1950 (RP2133 to RP2144, incl.).

Technical News Bulletin, volume **34**, number 10, October 1950. 10 cents.

CRPL–D74. Basic Radio Propagation Predictions for January 1951. Three months in advance. Issued October 1950. 10 cents.

Research Papers

RP2123. Wide-range phase control with constant attenuation by adjustable impedance in a resistance-loaded bridged-tee network. Myron G. Pawley. 10 cents.

RP2124. Stability of dextrose solutions of varying pH. Emma J. McDonald. 10 cents.

RP2125. Infrared spectrum of chlorofluoromethane. Earle K. Plyler and Mary A. Lamb. 10 cents.

RP2126. Resin bonding of hardwood fibers in offset papers. Bourdon W. Scribner, Merle B. Shaw, Martin J. O'Leary, and Joshua K. Missimer. 10 cents.

RP2127. Determination of very small changes in rate over intervals of several days in mechanical timepieces. Horace A. Bowman. 10 cents.

RP2128. A sulfate susceptibility test for portland cements. W. C. Taylor and R. H. Bogue. 10 cents.

RP2129. Cascade-connected attenuators. Robert W. Beatty. 10 cents.

RP2130. Total ionization of hydrocarbons from mass spectral data. Fred L. Mohler, Laura Williamson, and Helen M. Dean. 10 cents.

RP2131. Generalization of S. Bernstein's polynomials to the infinte interval. Otto Szasz. 10 cents.

RP2132. Numerical determination of characteristic numbers. W. E. Milne. 10 cents.

Circulars

C495. Heat treatment and properties of iron and steel. Samuel J. Rosenberg and Thomas G. Digges. 25 cents.

C497. Research on dental materials at the National Bureau of Standards. I. C. Schoonover and Wilmer Souder. 15 cents.

C498. Bibliography of recent research in the field of high polymers. Robert Simha, Irma G. Callomon, Mary Budge Gaughan, and Helen H. Jeppson. 20 cents.

C499. Nuclear data. A collection of experimental values of half-lives, radiation energies, relative isotopic abundances, nuclear moments, and cross sections. Compiled by Katharine Way, Lilla Fano, Millicent R. Scott, and Karin Thew. $4.

Handbooks

(Correction Sheets)

Correction sheets, changes adopted by the Thirty-fifth National Conference on Weights and Measures, 1950. (To supplement H44, Specifications, tolerances, and regulations for commercial weighing and measuring devices.) Available upon request from the National Bureau of Standards, Washington 25, D. C.

Miscellaneous

M198. Annual report of the National Bureau of Standards, 1949. 75 cents.

Simplified Practice Recommendations

R8–50. Ferrous range boilers, expansion tanks, and solar tanks. (Supersedes R8–47.) 5 cents.

R118–50. Abrasive grain sizes. (Supersedes R118–45.) 5 cents.

U. S. GOVERNMENT PRINTING OFFICE: 1950